Original Research Article

Application of Sulphur Levels and Different Micronutrients on Yield and its Attributing traits of Garlic (*Allium sativum* L.)

ABSTRACT

The field experiment was conducted at the Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during 2019-20 and 2020-21. The experiment consisted of 20 treatment combinations with four soil application of sulphur (S_0-control, S_1-sulphur 20 kg/ha, S_2-sulphur 40 kg/ha and S_3-sulphur 60 kg/ha) and five levels of foliar application of micronutrients (M_0-Control, M_1-zinc sulphate @ 0.6%, M_2-ferrous sulphate @ 0.2%, M_3-borax @ 0.5 and M_4-Ammonium molybdate @ 0.5%) in Factorial Randomized Block Design with three replications. The results of the study have clearly indicated that among sulphur levels, application of sulphur 60 kg/ha significantly improved growth parameters viz., neck thickness, number of cloves per plant, clove length, clove girth, polar diameter, equatorial diameter, enhanced significantly by application of sulphur 60 kg/ha (S_3) in both the years as well as in pooled analysis. Similarly, among micronutrients foliar application of zinc sulphate @ 0.6% significantly influenced all the growth, yield attributes viz., neck thickness, number of cloves per plant, clove length, clove girth, polar diameter, equatorial diameter of garlic in both the years as well as in pooled analysis.

Keywords: *Garlic, Sulphur, Micronutrients, Clove length and Diameter of bulb.*

1. INTRODUCTION

Garlic is an important bulbous plant and used throughout India primarily as a spice or condiment. It is botanically known as *Allium sativum* L. is member of the genus *Allium*, which comprises approximately 750 species belonging to the family Alliaceae. It is one of the most important bulbous vegetable crop and is next to onion [1]. It is originated from Central Asia and later spread to Mediterranean region [2] and [3].

The bulb of garlic is compound in nature, consisting of numerous bulblets, so called as cloves, of different size, the whole surrounded by layers of white scale leaves. Allicin is the main biologically active component of freshly crushed garlic cloves, which is produced by the degradation of alliin, from results of alliinase activity [4] and [5]. It has many medicinal properties. It lowers blood cholesterol levels and antiplatelet aggregation, produces anti-inflammatory activity and inhibits cholesterol synthesis. Moreover, it has long been known to have antibacterial, antifungal, anticancer, antioxidant and antiviral activities [6].

Nutrient are the product of the magnitude of impacts crop yield per unit area. Plant requires essential nutrients for normal functioning and growth. Deficiency of micronutrients during the last three decades has become a major constraint to production and productivity of vegetables in general and garlic in particular. Thus, there is an urgent need for correction of individual nutrient deficiency and for arresting its further spread. The lower productivity of Indian garlic is primarily due to cultivation of low yield potential varieties/hybrids, susceptibility to both biotic and abiotic factors. Therefore, imbalanced nutrition is treated as one of the major abiotic factors which adversely affects growth and yield of garlic.

Application of boron can increase bulb size, number of cloves per bulb and yield of garlic [7]. Zinc is crucial for plant growth because it controls the synthesis of indole acetic acid, which noticeably regulates plant growth and also active many enzymatic reactions which are necessary for chlorophyll synthesis and carbohydrate formation [8]. Iron is an essential micronutrient for almost all living organisms because it plays critical role in metabolic processes such as DNA synthesis, respiration and photosynthesis. Further, many metabolic pathways are also activated by iron and it is a prosthetic group constituent of many enzymes. An imbalance between the solubility of iron in soil and the demand for iron by the plant are the primary causes of iron chlorosis. Molybdenum is also an important micronutrient for plants, which plays a vital role in enzymes activity as nitrogenase, catalase and peroxidase [9] and [10].

Among the macronutrients, sulphur is one of a major plant nutrient essential for building up pungency in garlic is attributed to presence of an alkaloid "Di allyl disulphide" in which sulphur is prime component. Sulphur application in crops is not only important from nutrient point of view but also it builds resistance in plants against pest and diseases. Its role in balanced fertilization and consequently in yield and quality enhancement of garlic is being increasingly appreciated.

2. MATERIAL AND METHODS

The field experiment **"**Effect of Sulphur and Micronutrients on Growth, Yield and Storage of Garlic (*Allium sativum* L.)" was conducted at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during *Rabi* seasons 2019-20 and 2020-21. The experiment was laid out at Horticulture farm, S.K.N. College of Agriculture, Jobner, District Jaipur (Rajasthan) during *Rabi* season 2019-20 and 2020-21. Geographically, Jobner is situated 45 km in West of Jaipur at 26°5’ North latitude,75°20’ East longitude and at an altitude of 427 meters above mean sea level. This region falls under Agro-Climatic Zone-IIIA (Semi- Arid Eastern Plain Zone) of Rajasthan.

The climate of Jobner region is typically semi-arid characterized by extremes of temperature both in summer and winter, low rainfall and moderate relative humidity. The annual average rainfall varies between 250 to 500 mm, most of which is received in rainy season fall during July to early September, sporadic showers also received in winters. The maximum temperature ranges from 30 to 46ºC during month of May and June, while in December and January, it falls down below -1ºC and evaporation ranges from 1.2-6.9 mm per day.

The experiment was laid out in factorial randomized block design with three replications consisting of twenty treatment combinations including four micronutrients (control, Borax at 0.5 %, Zinc sulphate at 0.6%, Ferrous sulphate at 0.2% and Ammonium molybdate at 0.5% and five sulphur levels (control, 20, 40 and 60kg/ha). The sulphur were applied as soil application just before sowing and micronutrients (Zn, B, Fe and Mo) as foliar spray at 40 DAS. Recommended dose of inorganic fertilizers applied uniformly in whole experimental area. The plot size was 1.5 × 1.2 m2 (1.80 m^2) and seed are sowing at spacing of 15 cm x 10 cm. The seeds of cv. G -282 procured from NHRDF, Karnal (Haryana). The seeds (cloves) of garlic were first treated with Carbendazim @ 2 g/kg seed to control seed borne diseases. The seeds were sown on 16thOctober, 2019 and 22th October, 2020 manually with a seed rate of 500 kg /ha in row at 15 cm apart. All the cultural operations were followed continuously during crop growth. The observations were recorded for different yield parameters like neck thickness, polar diameter, and equatorial diameter, number of cloves per bulb, clove length and girth.

3. RESULTS AND DISCUSSION

Effect of sulphur levels

The data pertaining to the effect of various levels of sulphur on yield parameters of garlic revealed that all the treatments significantly influenced the neck thickness, polar diameter, equatorial diameter, number of colves per bulb, clove length and girth of garlic (Table 1, 2 and 3) during both the years and in pooled mean analysis. The maximum neck thickness (0.750, 0.795 and .773), polar diameter (4.96, 5.12 and 5.04), equatorial diameter (3.79, 3.94 and 3.87), number of clove per bulb (17.88, 17.00 and 17.44), clove length (2.79, 2.91 and 2.85) and clove girth (1.04, 1.08 and 1.06) was found in treatment S_3(Sulphur -60 kg/ha) during the year 2019-20 and 2020-21 as well as in pooled mean analysis, respectively. However, the treatment S_3 was found statistically at par to S_2 (Sulphur- 40 kg/ha). This might be due to magnificent role of sulphur is a key nutrient in garlic production; therefore, lack of its optimum supply in different plant parts limits the crop quality and also had poor utilization of macro and micronutrients [11]. These results are agreement with findings of [12] in garlic, [13] in onion and garlic, [14], [15] in garlic, [16] and in onion [17].

Effect of Micronutrients

Data indicated that application of various micronutrients also had significant effect on the yield parameters of garlic during both the years and in pooled mean analysis (Table 1, 2 and 3). The foliar spray of zinc sulphate-0.5 % (M_1) registered maximum neck thickness (0.749, 0.784 and 0.767), polar diameter (4.88, 4.99 and 4.94), equatorial diameter (3.71, 3.87 and 3.79), number of clove per bulb (17.70, 16.84 and 17.27), clove length (2.78, 2.88 and 2.83) and clove girth (1.04, 1.07 and 1.05) which were significantly higher over rest of the treatments except M_2 (ferrous sulphate @ 0.2%), M_3 (borax @ 0.5%) and M_4 (ammonium molybdate @ 0.5%) in both the years and pooled mean analysis which was found statistically at par to it. Zinc is crucial for plant growth because it controls the synthesis of indole acetic acid, which noticeably regulates plant growth and also active many enzymatic reactions which are necessary for chlorophyll synthesis and carbohydrate formation [8]. Application of zinc also play a role to increase the activity of nitrate reductase enzyme and enhanced synthesis of certain amino acids and protein. The results are also supported by [18] in tomato, [19] in okra, [20] in garlic, [21] in onion.

4. CONCLUSION

Based on the results of two years experiments, it may be concluded that soil application of sulphur at 60 kg/ha combined with foliar spray of Zinc sulphate at 0.6% proved the most superior treatment combination in garlic fetching the significantly higher net returns (Rs. 286296/ha), B: C ratio (2.92) and total bulb yield (192.18 q/ha). Although, sulphur application at 40 kg/ha along with foliar application of zinc at 0.6 % was found at par to it.

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Table 1 Effect of sulphur and micronutrients on diameter of bulb (polar and equatorial) of garlic

Treatments	Polar diameter (cm)			Equatorial diameter (cm)		
	2019-20	**2020-21**	**Pooled**	**2019-20**	**2020-21**	**Pooled**
A. Sulphur						
S_0 (Control)	4.23	4.28	4.26	3.19	3.33	3.26
S_1 (Sulphur 20 kg/ha)	4.55	4.68	4.62	3.45	3.60	3.53
S_2 (Sulphur 40 kg/ha)	4.86	5.02	4.94	3.69	3.86	3.78
S_3 (Sulphur 60 kg/ha)	4.96	5.12	5.04	3.79	3.94	3.87
SEm±	0.10	0.12	0.08	0.07	0.08	0.05
CD (P=0.05)	0.28	0.33	0.21	0.20	0.23	0.15
B. Micronutrients						
M_0 (Control)	4.28	4.37	4.32	3.26	3.37	3.32
M_1 (Zinc sulphate @ 0.6%)	4.89	4.99	4.94	3.71	3.87	3.79
M_2 (Ferrous sulphate @ 0.2%)	4.68	4.83	4.76	3.54	3.71	3.63
M_3 (Borax @ 0.5%)	4.79	4.89	4.84	3.62	3.81	3.71
M_4 (Ammonium molybdate @ 0.5%)	4.62	4.79	4.70	3.51	3.65	3.58
SEm±	0.11	0.13	0.09	0.08	0.09	0.06
CD (P=0.05)	0.32	0.37	0.24	0.23	0.25	0.17

Table 2. Effect of sulphur and micronutrients on number of cloves per bulb and neck thickness of garlic

Treatments	Number of cloves per bulb			Neck thickness		
	60 DAS			At harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
A. Sulphur						
S_0 (Control)	16.42	15.53	15.98	0.630	0.639	0.635
S_1 (Sulphur 20 kg/ha)	17.38	16.46	16.92	0.690	0.735	0.713
S_2 (Sulphur 40 kg/ha)	17.81	16.92	17.37	0.730	0.779	0.755
S_3 (Sulphur 60 kg/ha)	17.88	17.00	17.44	0.750	0.795	0.773
SEm±	0.32	0.31	0.22	0.013	0.015	0.010
CD (P=0.05)	0.91	0.89	0.63	0.037	0.043	0.028
B. Micronutrients						
M_0 (Control)	16.46	15.54	16.00	0.625	0.653	0.639
M_1 (Zinc sulphate @ 0.6%)	17.70	16.84	17.27	0.749	0.784	0.767
M_2 (Ferrous sulphate @ 0.2%)	17.55	16.64	17.10	0.712	0.752	0.732
M_3 (Borax @ 0.5%)	17.65	16.80	17.22	0.731	0.772	0.752
M_4 (Ammonium molybdate @ 0.5%)	17.49	16.57	17.03	0.683	0.723	0.703
SEm±	0.35	0.35	0.25	0.015	0.017	0.011
CD (P=0.05)	0.070	0.074	0.050	0.042	0.048	0.031

Table 3 Effect of sulphur and micronutrients on clove length and girth of garlic

Treatments	Clove length (cm)			Clove girth (cm)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
A. Sulphur						
S_0 (Control)	2.39	2.45	2.42	0.88	0.90	0.89
S_1 (Sulphur 20 kg/ha)	2.57	2.64	2.61	0.96	0.98	0.97
S_2 (Sulphur 40 kg/ha)	2.71	2.80	2.76	1.01	1.04	1.03
S_3 (Sulphur 60 kg/ha)	2.79	2.91	2.85	1.04	1.08	1.06
SEm±	0.05	0.05	0.03	0.02	0.02	0.01
CD (P=0.05)	0.13	0.15	0.10	0.05	0.06	0.04
B. Micronutrients						
M_0 (Control)	2.39	2.45	2.42	0.89	0.91	0.90
M_1 (Zinc sulphate @ 0.6%)	2.78	2.88	2.83	1.04	1.07	1.05
M_2 (Ferrous sulphate @ 0.2%)	2.63	2.71	2.67	0.97	1.01	0.99
M_3 (Borax @ 0.5%)	2.73	2.83	2.78	1.01	1.04	1.02
M_4 (Ammonium molybdate @ 0.5%)	2.56	2.63	2.59	0.96	0.97	0.97
SEm±	0.05	0.06	0.04	0.02	0.02	0.01
CD (P=0.05)	0.15	0.16	0.11	0.05	0.06	0.04